# A Bell Telegraph

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**Abstract**

We show a device with which, apparently, information (in the form of a "slash-dot" code) is instantly transmitted via Bell state collapse, over arbitrary distance. We discuss some problems and paradoxes arising when this conclusion is viewed in the relativistic framework.

## 1 Introduction

Bell states [1] are a direct consecuence of quantum mechanics, which have been profusely seen in experiments [2] Both theory and experiment tell that measurements at one place causes quantum state collapse of parts arbitrarily far away, "instantly". But it has been argued that no information can be carried in such processes. If this were not the case, there would be a clash with relativity, since simultaneity is not an invariant concept so one should wonder what is the frame in wich the collapse is instantaneous.

Here we show a device in wich, via Bell states, information seems to travel instantly between distant points. We haven't been able to find why it should not work, although we find that such a device would cause serious conceptual problems and even paradoxes.

In the next section we describe the device and how it works. Then, in the last section, we show some problems and paradoxes occurring at the relativistic realm.

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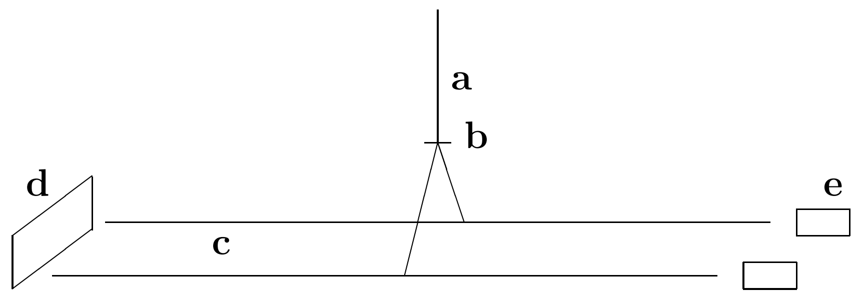
## 2 The device




Scheme of the telegraph. A beam of excited atoms (a) splits at a potential barrer (b). Then each atom decay at any of two pipes (c) emitting two correlated photons. At one end (d) they are set to interfere with themselves at a screen. At the other end (e), two detectors are placed, which can be turned on or off

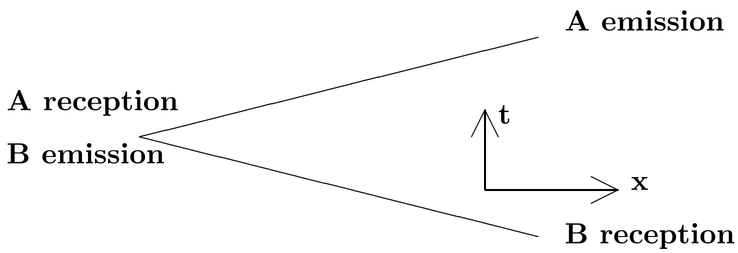
A sketch of the device is shown in the figure above. It is inspired in Feynman's discussion on quantum interference [3]. A beam of excited atoms (wich will emit a two photon Bell state) is divided in two by a potential barreer in such a way that a given atom has the same probability of following each path, wich is itself a Bell state. At the decay, the resulting photons are collected by some kind of pipes (for instance, two optic fabrics), so every pair of photons is in any of those, forming a kind of doubly entangled state. If no one collapses this system, the photons at one end of the pipes can be set to interfere at a screen. But one could 'see' where each pair is just looking at the second photon at the other end, destroying the interference pattern. So, turning on and off detectors at one end sets the other end at two observably different states (random arrival and interference respectively), wich can obviously be used as a telegraph.

Still we have to show that this can indeed be used to send information in a time as short as necessary to be considered instantaneous. We need several photon pairs (say M) to conclude that we are before an interference or not, with a given confidence interval. One solution is to use many uncorrelated pairs simultaneously, and invoke superposition principle. But in order not to obscure the conclusions by adding hypothesis, we will give an alternative proof using single pairs. Suppose that for a given telegraph we need a time separation T for producing each pair being sure that we deal with a single pair at a given instant. So we need a time MT for sending a "byte". Now take N such telegraphs, in which the first pair in each is produced in an instant at random between 0 and T. With this ensemble we build an improved telegraph, turning on and off all detectors simultaneously for sending signals. Now the time needed reduces to MT/N, and can be made as little as we wish. Thus we can send information instantly (at the large N limit) using (lots of) single pair states.

# 3 Troubles

Let's suppose for the moment that we haven't done any mistakes; if so, quantum mechanics imply we can send information instantly. What do we mean by "instantly" in a relativistic context? Or, put differently, instantly in what reference frame? This is a difficulty with the very concept of quantum collapse. Even if it turns that no information could be transmitted via Bell states, this is still a conceptual puzzle. Whatever the answer is, fits in any of the following two posibilities:

- **Deny relativity:** There is a privileged frame F in which quantum collapse occur instantly. This possibility is not inconsistent but deeply nasty.
- **Preserve relativity:** The frame F in which the collapse is instantaneous depends on the state (for instance, it could be the one in which the center of mass is at rest). This possibility seems more acceptable, but a closer look shows it leads to inconsistencies, which can be seen as paradoxes. Consider the setting shown in the figure below: two identical telegraphs A and B with F(A) and F(B) moving in opposite directions results in sending a signal to the past. As F(A) moves to the left, A reception happens before A emmision in this frame. The message is instantly retransmitted trough B (B emmision) and again, as F(B) moves to the right, B reception happens before B emission, and at the same space location than A emmision. In the setting, the automaton located there transmit $m_1$ if and only if it transmit $m_2$ and vice versa, wich is absolutely inconsistent.




Setting for the paradox: two identical and opposely oriented tellegraphs A and B has F(A) and F(B) respectively as frames where communication is instantaneous. F(A) moves toward the left at some speed v, while F(B) is set to move towards the right at speed v, and we produce the A emission in a moment such that A reception and B emission coincides. The message received from A is retransmitted through B. An automaton able to send either message $m_1$ or $m_2$ stay still at the position of A emission, wich is the same than B reception, and we set it to send $m_1$ throug A if it reads $m_2$ from B and vice versa.

Of course, there remain the possibility that we have done some mistake and quantum mechanics really forbids such a device to work. Hopefully this work will call someone's attention in order to find it out.

# 4 Aknowledgements

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# References

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For a modern review, see Galindo and Martin-Delgado, quant-ph/0112105 and references therein

[3] The Feynmann Lectures on Physics, vol. 3, chapter 1.